BIODEGRADABILITY OF POTATO-PROCESSING WASTES

DIVISION OF RESEARCH

ONTARIO WATER RESOURCES COMMISSION

January, 1968 R. P. 2013

BIODEGRADABILITY OF POTATO-PROCESSING WASTES

By:

S. A. Black

January, 1968

Division of Research
Paper No. 2013

INTRODUCTION

There are several potato-processing industries within the Province of Ontario which are contributing large volumes of highly concentrated organic wastes to our waterways. It has been apparent for some time that some method of advanced treatment must be introduced at these plants. Although there has been considerable research carried out on the treatment of potato wastes, no method of treatment has proven entirely successful and the cost of treatment of these high strength wastes prohibits the construction of unproven processes. There has been little investigation into the use of the activated sludge process method of treatment for potato wastes.

The reason for the skepticism in the use of the activated sludge process for the treatment of potato wastes apparently lies in the nature of the waste. Because of the high strength of the waste, it has been thought that conventional methods of treatment would be too expensive. The waste, however, is very easily stabilized by biological processes and studies by Sproul (1963) and Atkins and Sproul (1964) have shown that potato-processing wastes are highly amenable to treatment by standard biological processes. BOD

removals of 95 percent were obtained by activated sludge treatment at loadings of 80 lb BOD/1,000 lb MLSS/hr aeration. High-rate trickling filtration of this waste gave BOD removals of 88% or better at loadings of 3,000 lb BOD/day/acre-ft. Further studies demonstrated that potato-processing wastes can be treated by a completely mixed activated sludge system, without pH adjustment of the incoming waste, at a solids level (MLSS) of 4,000 mg/l and a detention period of 6 to 8 hours, BOD reduction of 95% or greater might be expected.

This particular study was carried out in order to confirm the amenability of potato-processing wastes to the activated sludge method of treatment and to define some of the operating variables involved.

STUDY METHOD

A typical potato-processing plant employing the lye-peeling system was chosen as the waste source for this study. Processing at the plant includes the production of "french-fries", chips and instant mashed and scalloped potatoes. No attempt was made to investigate the individual wastes from the various process streams; instead, the combined waste from the entire plant was studied.

The combined waste from the plant receives primary sedimentation before being passed on to a municipal aerated lagoon system, which is greatly overloaded at present. Samples used for this study were collected daily from the primary clarifier effluent and refrigerated until used.

At the time of the study, the plant was partially shut down for the summer holiday period and the waste was considerably lower in strength than normal for the plant.

The model sewage treatment plant used for this study was of a continuous flow, combined aeration-settling tank design as described in Research Paper 2011 (Black, 1967).

The model plant was started up on a domestic sewage feed with mixed liquor obtained from a municipal activated sludge plant. Potato waste was then mixed with the influent domestic sewage at increasing concentrations until, in about two weeks time, the sludge had become acclimatized to a feed of 100% potato waste. During this time the detention period of the plant was decreased from 24 hours to 7 hours total detention providing 4.5 hours aeration and 2.5 hours settling.

The plant was operated at a detention time of 7 hours for 15 consecutive days. Detention was then decreased to 4.3 hours.

To study the treatment provided by the model plant, analyses of BOD, COD, solids, nitrogens and phosphorus were made on the plant influent and effluent according to Standard Methods. Determinations of mixed liquor suspended and volatile suspended solids were made to investigate sludge growth relationships. Oxygen utilization rates were obtained with the apparatus also described in Research Paper 2011 in order to determine the oxygen requirements of the process.

EXPERIMENTAL RESULTS

Characteristics of Waste Feed

Lye-peeled potato-processing wastes are characteristically high in pH, generally lying between pH 10 and 11. As the waste feed for this study was obtained from the primary clarifier effluent, however, it had a maximum pH of 10.5 and averaged 9.3. Since Atkins and Sproul (1964) found that activated sludge may be acclimatized to a potato waste feed of pH 11, it was decided that this study would be carried out with no pH adjustment.

Preliminary analyses on the waste indicated a BOD:N:P ratio in the order of 100:7:8, which, according to Eckenfelder and O'Connor (1964), indicates adequate nutrients for biological degradation. No nutrient addition was deemed necessary.

The characteristics of the settled waste are presented in Table 1. As can be seen, the strength of the waste varied greatly throughout the study. BOD values ranged from a high of 940 ppm to a low of 205 ppm. These values are somewhat lower than those reported in the literature, partially because the waste had already received primary sedimentation

reducing the BOD and SS content by approximately 30 and 60%, respectively (Francis, 1962) and partially because of the plant slowdown over the summer period.

Table 1

CHARACTERISTICS OF SETTLED POTATO-PROCESSING WASTE*

	BOD	COD	SS	Nitrogen as N KN**	NH_3	Phosphorus as PO_4 Tot.	Sol.
Max.	940	4840	752	61	25.0	55	35
Min.	205	510	228	8	5.8	30	15
Avg.	470	1442	416	34	13.0	38	23

* Units per ppm

** KN = Total Kjeldahl Nitrogen

Treatment Results

The accumulated data resulting from the model plant study is presented in Table 2. Initially, the plant was operated at an aeration detention of 4.5 hours with sampling carried out over a period of 15 days. During this time there was no wasting of sludge and as can be seen from Table 2, the MLVSS content remained fairly constant, averaging 3030 ppm. The oxygen utilization rate of the mixed liquor reflected its solids content rather than the organic loading. At this

detention, BOD and suspended solids reduction averaged 95 and 92%, respectively. Effluent BOD and SS concentrations averaged 20 and 24 ppm, respectively.

At the aeration period of 4.5 hours, a very heavy sludge with a Mohlman sludge volume index (SVI) of 55 to 60 was produced which settled readily in the settling unit of the combined tank.

At a total detention of 4.3 hours (2.75 hours aeration) the results shown in Table 2 indicate even better treatment than at the longer retention. Observations of the plant, however, indicated much poorer treatment. As can be seen the MLSS decreased from day to day. This was because solids had to be wasted each day to maintain a satisfactory effluent due to the increasing bulkiness of the mixed liquor. Between the 2nd and 5th day of operation at this detention the SVI increased from 78 to 150. By the 6th day the index reached 260 and there was such a high carry over of solids that sampling was discontinued.

Table 2

RESULTS OF PILOT PLANT STUDY

Days of Operation	BOD In ppm	BOD Out ppm	BOD Redn %	COD In ppm	COD Out ppm	COD Redn %	SS In ppm	SS Out ppm	SS Redn %	MLSS (ppm)	MLVSS (ppm)	pH In	pH Out	O_2UR (ppm/hr)
4.5 hrs Aeration														
5	840	26	97	1220	95	92	327	36	89	-	-	-	-	38
6	600	21	97	510	61	88	256	30	88	4208	3040	9.1	8.0	48
7	370	19	95	927	69	93	270	21	92	4754	3384	8.6	7.7	48
8	205	17	92	1470	105	93	356	22	94	5806	3980	9.1	7.7	70
12	320	28	91	966	68	93	506	4	99	3928	2496	8.8	7.9	36
13	245	19	92	860	61	93	322	29	91	4496	2972	10.2	7.7	42
14	240	7	97	2410	28	99	228	34	85	3952	2660	9.5	7.3	37
15	440	12	97	4840	333	94	648	16	98	4186	2688	9.6	7.6	38
2.75 hrs Aeration														
17	570	16	97	875	66	92	616	23	96	-	-	10.5	8.4	-
18	940	8	99	1180	80	93	752	14	98	5060	3668	9.2	8.3	65
19	510	11	98	1280	74	94	432	12	97	4104	3092	8.9	7.9	40
20	360	10	97	780	36	95	270	21	92	3052	2232	9.3	7.9	32

DISCUSSION

This study indicated that potato-processing wastes, after receiving primary sedimentation, are highly compatable with the activated sludge process method of waste treatment. The relative high pH of the waste had no effect on treatment and the waste was found to contain ample nutrients to support biological growth.

At an aeration detention period of 4.5 hours a well-developed mixed liquor with good settleability was established. A MLSS content of approximately 4,000 mg/l was established and maintained with no sludge wasting required. Loadings at this detention ranged from 32 to 148 lb BOD/1,000 cu ft or from 0.192 to 0.562 lb BOD/lb MLSS/day.

The oxygen utilization rate as presented in Table 2 appears to reflect the MLSS content more so than the influent waste strength. Eckenfelder and O'Connor (1964), pg. 40, states that total oxygen requirements of a bio-oxidation system can be defined as:

lb O_2/day = a' lb BOD_5 removed/day + b' lb MLVSS.

Using the data of Table 2 it may be calculated that a' approaches 0.371 and b' approaches 0.137. This value of b' is almost twice that of the reference, indicating a very high rate of endogenous respiration and thus accounting for the lack of sludge buildup during the operation of the model plant. It also indicates why the oxygen utilization rate reflects the MLVSS content more so than the influent waste strength.

Table 2 fails to reflect the operation of the pilot plant at a detention of 2.75 hours aeration. During the first five days of operation at this detention period a very high quality effluent was produced, with BOD and SS reduction averaging 98 and 96%, respectively. The conditions of the mixed liquor, however, indicated a rapid degradation in its quality. In order to maintain a good effluent, solids had to be continually wasted reducing the MLSS content from over 5,000 mg/l to 3,000 mg/l. By the 6th day of operation sampling was discontinued because of the high carry over of light floc in the final effluent. The oxygen uptake rate dropped off correspondingly with the decrease in MLVSS content.

Loadings at 2.75 hours aeration averaged 274 lb BOD/1,000 cu ft/day.

CONCLUSIONS

The following conclusions are presented as a result of model sewage treatment plant studies on potato-processing waste:

(1) Potato-processing wastes contain adequate nutrients for bio-oxidation.

(2) The high pH of lye-peeled potato wastes does not affect its bio-degradation.

(3) A BOD percent reduction in the order of 95% may be expected by an activated sludge plant, employing 4.5 hours aeration at a MLVSS content of 3,000 ppm treating potato processing wastes and at loadings of up to 150 lb BOD/ 1,000 cu ft/day. A very limited amount of sludge wasting will be required.

(4) An aeration period of 2.75 hours produces a light, bulky sludge which will not settle out and very poor treatment results.

(5) Oxygen is required at a rate of 1 lb for every 1.4 lb of BOD applied. At a transfer efficiency of 5%, air would have to be supplied at a rate of 850 cu ft/lb BOD applied.

REFERENCES

Atkins and Sproul (1964), "Feasibility of Biological Treatment of Potato-Processing Wastes", Journal WPCF, August, 1966.

Black (1967), "A Model Sewage Treatment Plant for Waste Treatability Studies", OWRC, Research Paper #2011, August, 1967.

Eckenfelder and O'Connor (1964), "Biological Waste Treatment", Pergamon Press, 2nd Edition, 1964.

Francis (1962), "Characteristics of Potato Flake Processing Wastes", Journal WPCF, March, 1962.

Sproul (1963), "Biological Treatment of Protein Water from Manufacture of Potato Starch", O. J. Sproul, Editor, Univ. of Maine, Orono, Maine, 1963.

Date Due